Space Weather Technical Forecast

Issued on Sunday, 19 March 2023 at 13:15 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Chance of G1/Minor Storm intervals with CME glance possible day 2 or 3 (20th or 21st) but low confidence. Chance of M-flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Low with peak C4 flare at 18/0716 UTC from AR3256 on the southeast limb. There are six numbered sunspot regions visible. AR3256 is the largest, consisting of a large leader and smaller trailer spot with some sporadic flux developments around both of these. AR3257 to the southeast of this has recently been re-evaluated as a unipolar region, despite its two distinct umbra, however further reassessment is possible as it rotates into view. New regions have also been numbered, including AR3259 in the southeast, and AR3258 and AR3260 in the northeast. These are generally small and simpler regions, however AR3259 and AR3260 may yet reveal more details as they also move into a less oblique viewing angle. No Earth-directed CMEs have been observed in the last 24 hours.

Solar Wind / Geomagnetic Activity: The solar wind speed, as measured at L1, was slightly elevated at around 410-480 km/s, with density near or below average. The total IMF strength Bt, was weak, around 6nT, with the north-south component Bz ranging between +/-6 nT. The phi angle was predominately positive (away from the Sun). Geomagnetic activity was Quiet to Unsettled (Kp 2-3).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) as measured at GOES-16 is slightly above background with a small rise in observed values during the last 24 hours, peaking 1.23pfu, however this is still well below the S1/Minor Storm level. The high energy electron flux (greater than 2MeV) has been at background with the associated 24-hour Electron fluence below Active (1e8 integrated pfu). At 19/0000 UTC the observed fluence was 2.95e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Low activity is most likely, but with a chance of increasing to Moderate at times with isolated M-flares. These most likely from AR3256 or AR3257 in the southeast, or from other regions rotating over the eastern limb.

Solar Wind / Geomagnetic Activity: A glancing CME impact is possible day 2 or early day 3 (20th or 21st) from the filament eruption from the southwest disc on 17 March, however this is low confidence. This will come alongside a muted connection to the fast wind from CH85/+ on day 2 (20th). A stronger fast wind connection is expected later in the period from CH86/- currently in the southeast, with Earth potentially encountering the CIR of this enhancement late on the day 4 (22nd). Mainly Quiet geomagnetic activity is expected day 1 (19th), increasing to Unsettled with Active intervals day 2, before easing again day 3 and 4 (21st) to be mostly Quiet again. Although This perhaps increasing to Active with a slight chance of G1/Minor storms with any CME arrival late on day 2 and continuing day 3. Any arrival of the CIR of CH86/- on day 4 will likely increase activity to Active with a chance of G1 Minor Storms.

Energetic Particles / Solar Radiation: High energy (greater than 10MeV) proton flux is expected to continue easing to background, albeit erratically, with no further significant

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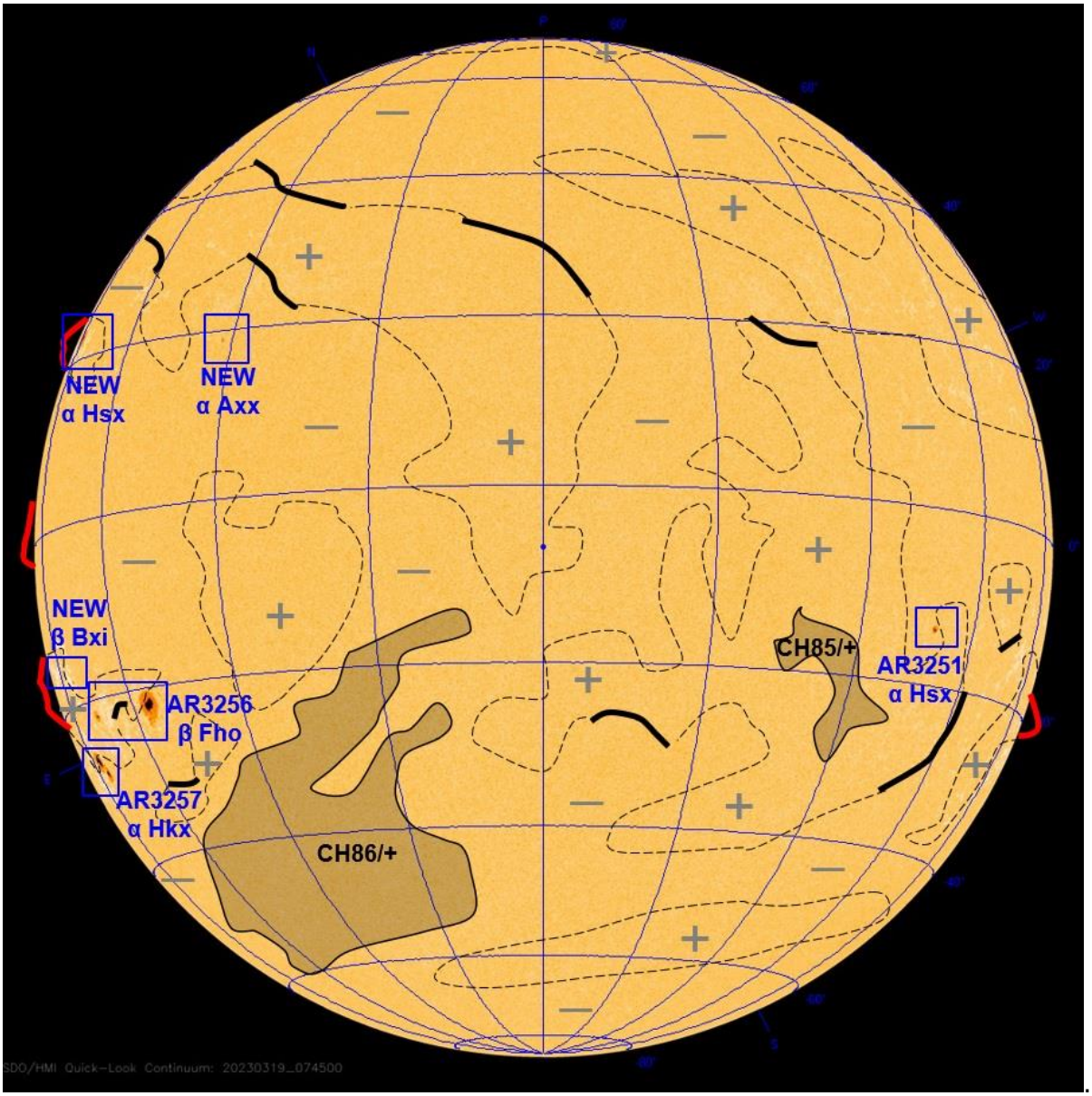
enhancements anticipated. The high energy electron flux is expected to persist largely at background, with a chance of rising to Moderate day 3 or 4 (21st or 22nd). The associated 24 hour fluence expected to remain below the Active threshold.

Figure 1. Solar Analysis Valid 19/0800 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

CME from 17 March has been assessed as passing mostly ahead and south of Earth, but with a chance of a glancing impact late on day 2 or early day 3 (20th or 21st). This is a low confidence forecast as coronagraph imagery is currently limited.

The fast wind associated with CH85/+ has the potential to bring some increased geomagnetic activity day 2 (20th) as Earth moves into its HSS. In the absence of any CME arrival this is likely be have a rather muted response, due to the Russel-McPherron effect, which results in positive features connecting less strongly near the March Equinox. However, alongside the low confidence CME, this gives a chance of activity increasing to G1/Minor storm later day 2 (20th).

CH86/-, currently located in the southeast disc, will then bring the next notable enhancement to the solar wind around Earth, with a likely arrival of a CIR region late on day 4 (22nd), or perhaps just after this period on the 23rd. This arrival time is supported by Enlil and persistence, however the feature has both retreated eastwards but also become more defined and darker in imagery since the previous rotation. Elevated winds are likely, perhaps exceeding 600km/s, as supported by persistence.

Mainly Quite geomagnetic activity day 1 (19th), increasing to Unsettled with Active intervals with any fast wind transition day 2 (20th), before easing day 3 and 4 (21st) to mostly Quiet again. This perhaps increasing to Active with a slight chance of G1/Minor storms with any CME arrival late on day 2 and continuing day 3. Any arrival of the CIR of CH86/- on day 4 will likely increase activity to Active with a chance of G1 Minor Storms.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	1	20	20	30
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
17/1610	Partial	Filament	SW Disc	510km/s	20/2100 UTC +/ 9 hrs	Low confidence. Glancing impact most likely

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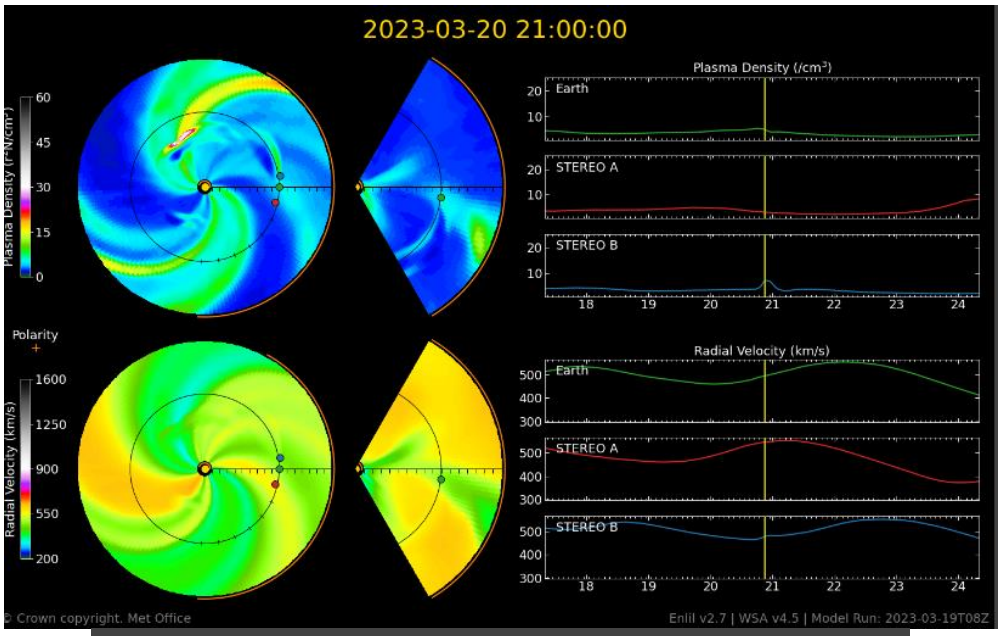
Figure 2a: Enlil and Ensemble showing CME glance



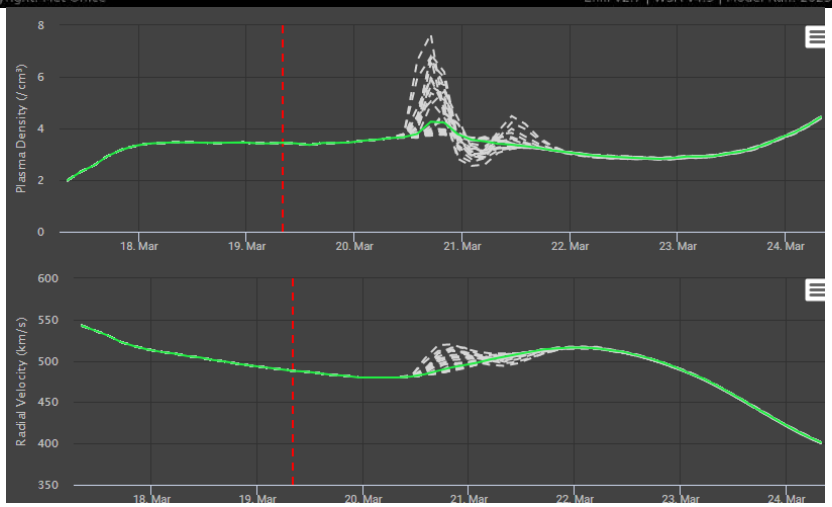
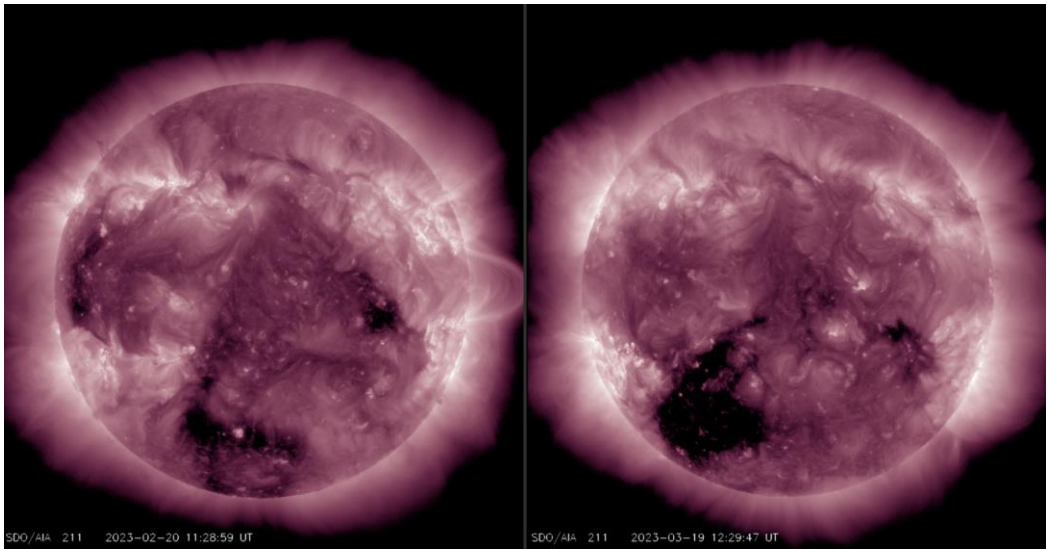


Figure 2b: SDO aia 211 of last rotation (left) and current (right).



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Radio Blackouts - X-Ray Flares:

Solar activity is expected to be Low with a chance of rising to Moderate each day, due to the risk of isolated M-flares. There remains a slight chance of X-class flares, with the potential for further regions to rotate on to the eastern limb through the period.

Of the six sunspot regions on the visible disc AR3256 Fho/Beta is the largest, comprising of a large leader region and a smaller trailer. Despite its longitudinal width and some ongoing evolution of the region, the spot has remained largely stable. To the southeast of this, AR3257 Hkx/Alpha is also gradually rotating into view. This was originally considered a bipolar region with two notable umbral areas aligned north-south, however it has become clearer that these regions are likely the same polarity. Also in the southeast disc, AR3259 Bxi/Beta is becoming visible to the northeast of the other spots. On the northeast limb, AR3260 Hsx/alpha is also rotating into view. All of these near limb regions have the potential to show further details as they move into a less oblique viewing angle.

There is also the potential for further regions to rotate onto the east limb, with significant looping visible on e.g. SDO aia-171, and far-side products such as Helioseismic images, showing a significant response to possible feature on the far-side.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	30	30	30	30
Very Active	R3 to R5 X Class	No	5	5	5	5

Figure 3a: GOES-16/18 X-ray Flux

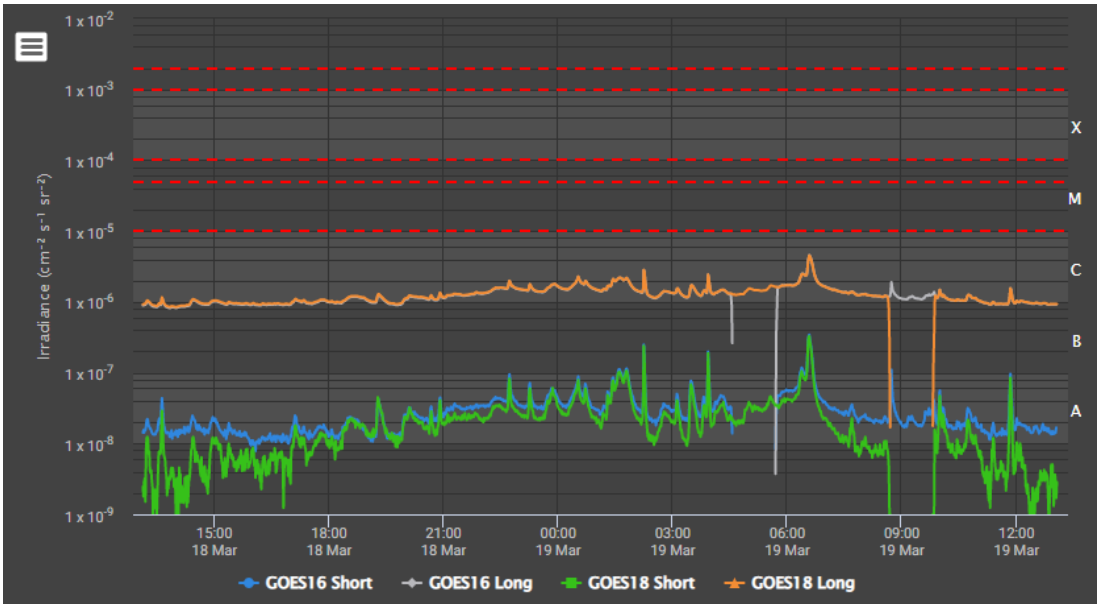

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Figure 3b: SDO hmi-intensitygram (left) and hmi-magnetogram (right) of SE disc.

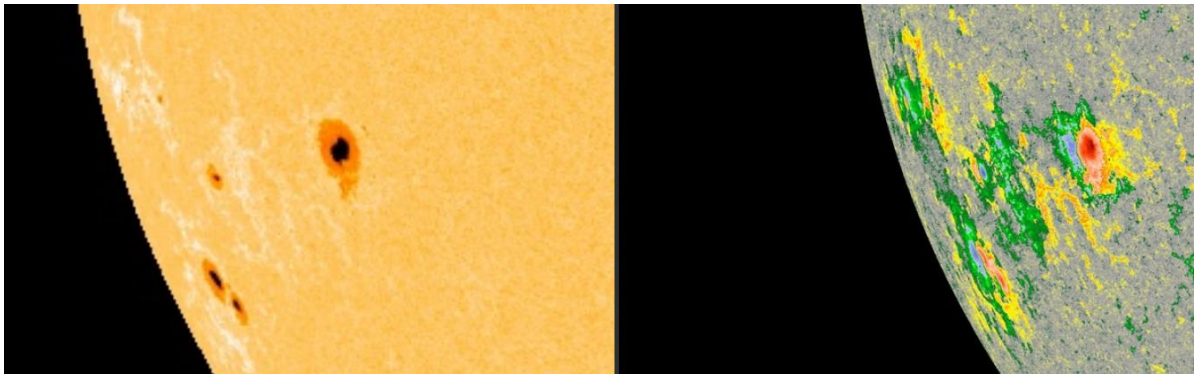


Figure 3c: SDO aia-171 showing significant magnetic looping on E limb (left) and STEREO A euvi imagery showing the potential for further regions to rotate on, especially NE limb (right)

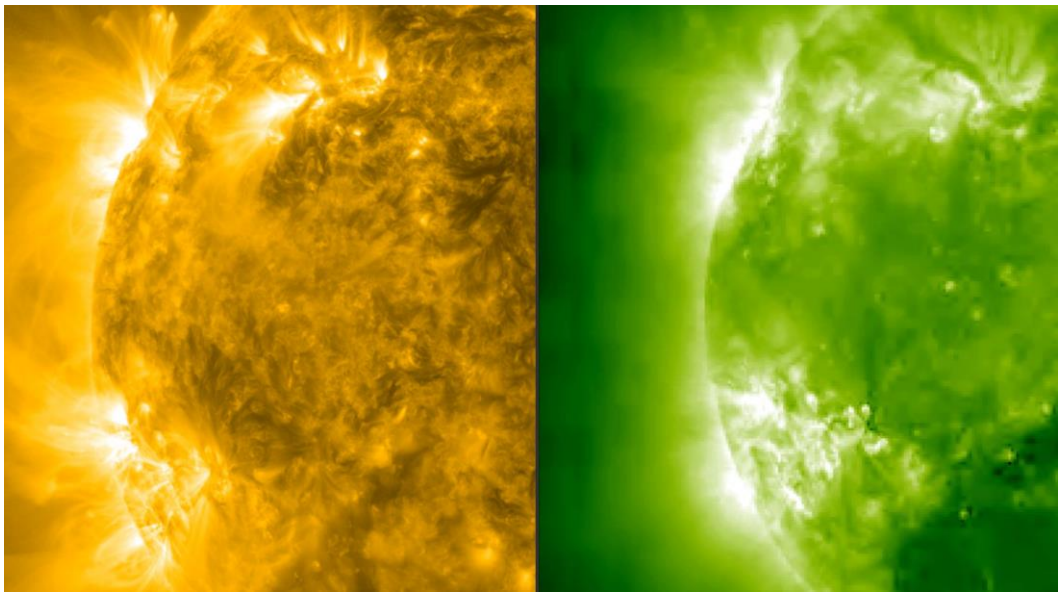
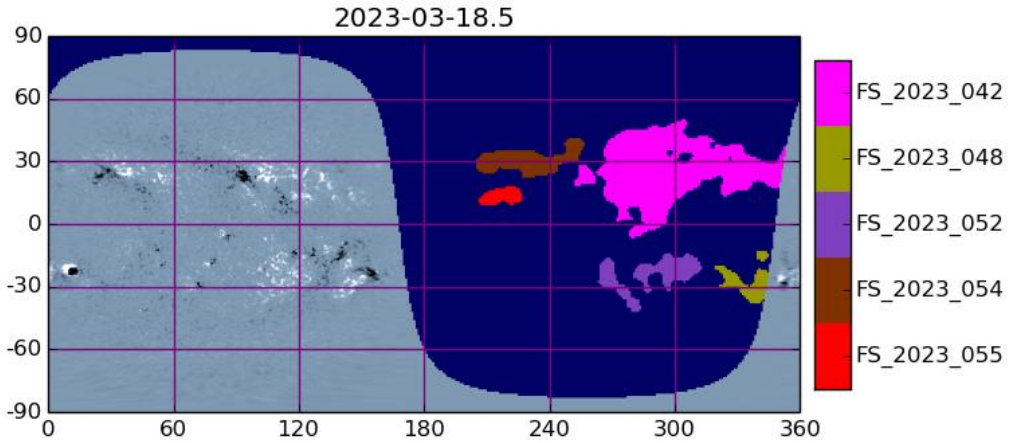


Figure 3d: Far-side helioseismic signal (from jscoc.stanford.edu), bright regions showing potential for further active areas to rotate onto the disc.



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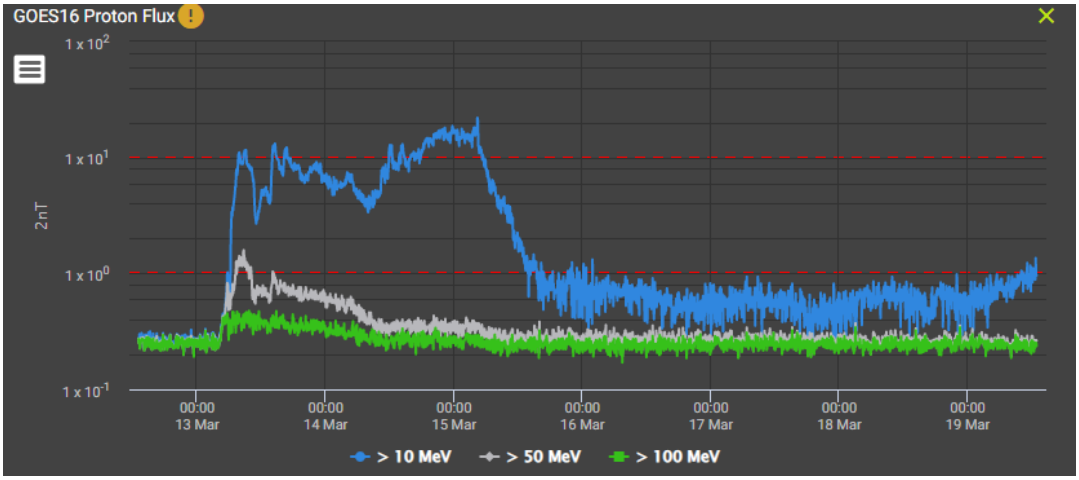
Solar Radiation Storms - (High Energy Protons):

High energy proton flux (greater than 10MeV), as observed by GOES-16 is currently very slightly above background as it continues to erratically decline from the S1 Minor Radiation storm event triggered by the large far-sided eruption on the 14th. No further notable proton enhancements are currently anticipated, with the most notable sunspot regions in a less favoured region for connection to Earth should any significant flares occur.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	1	1	1	1
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

Figure 4: GOES16 >10 MeV, >50MeV, >100 MeV flux for the last 7days,



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High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2MeV) electron flux observed by GOES-16 is expected to be mainly background through the period. A modest increase is possible later day 3 and day 4 (21st and 22nd) due to any enhanced solar wind environment from the fast wind of CH85/+ or potential glancing CME impact, however this is low confidence. This may bring periods of Moderate flux, with only very slight chance of briefly reaching High levels. Any CIR arrival ahead of CH86/- on day 4 will then likely result in flux levels dropping out again.

The associated 24 hour fluence is expected to be below the Active (1e8 integrate pfu) level with REFM currently giving good guidance.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	1	1
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: GOES 16 > 2MeV Electron Flux (top) and associated fluence with REFM (bottom)

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